CHAPTER II RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate and timely meteorological information in support of each warning. JTWC relies primarily on three sources of reconnaissance: aircraft, satellite and radar. Optimum utilization of all available reconnaissance resources is obtained through use of the Selective Reconnaissance Program (SRP) whereby various factors are considered in selecting a specific reconnaissance platform for each warning. These factors include: cyclone location and intensity, reconnaissance platform capabilities and limitations, and the cyclone's threat to life/property afloat and ashore. A summary of reconnaissance fixes received during 1979 is included in Section 6.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft:

Aircraft weather reconnaissance is performed in the JTWC area of responsibility by the 54th Weather Reconnaissance Squadron (54 WRS). The squadron, presently equipped with six WC-130 aircraft, is located at Andersen Air Force Base, Guam. From July through October, augmentation by the 53rd WRS at Keesler Air Force Base, Mississippi brings the total number of available aircraft to nine. The JTWC reconnaissance requirements are provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). These requirements include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times and forecast positions of fixes. The following priorities are utilized in acquiring meteorological data from aircraft, satellite and land-based radar in accordance with CINCPACINST 3140.1N:

"(1) Investigative flights and vortex or center fixes for each scheduled warning in the Pacific area of responsibility. One aircraft fix per day of each cyclone of tropical storm or typhoon intensity is desirable.

(2) Center or vortex fixes for each scheduled warning of tropical cyclones in the Indian Ocean Area of responsibility.

(3) Supplementary fixes.

(4) Synoptic data acquisition."

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight-level winds, sea level pressure, estimated surface winds (when observable) and numerous additional parameters. The meteorological data are gathered by the Aerial Reconnaissance Weather Officers (ARWO) and dropsonde operators of Detachment 4, Hq AWS who flew with the 54th. These data provide the Typhoon Duty Officer (TDO) indications of changing cyclone characteristics, radius of cyclone associated winds, and present cyclone position and intensity. Another important aspect of this data is its availability for research in tropical cyclone analysis and forecasting. Aircraft reconnaissance will become even more important in years to come when high-resolution tropical cyclone dynamic steering programs will require a dense input of wind and temperature data.

b. Satellite

Satellite fixes from USAF ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions and estimates of storm intensities through the Dvorak technique (for daytime passes).

Detachment 1, 1st Weather Wing, which receives and processes DMSP data, is the primary fix site for the northwestern Pacific. DMSP fix positions received at JTWC from the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska were the major source of satellite data for the Indian Ocean. GOES fixes were also provided by the National Environmental Satellite Service, Honolulu, Hawaii for tropical cyclones near the dateline.

c. Radar

Land radar provides positioning data on well developed cyclones when in proximity (usually within 175 nm of the radar site) of the Republic of the Philippines, Taiwan, Hong Kong, Japan, the Republic of Korea, Kwajalein, and Guam.

d. Synoptic

In 1979, the JTWC also determined tropical cyclone positions based on the analysis of the surface/gradient level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft were not available due to flight restrictions.

3. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1979 tropical season, the JTWC levied 289 six-hourly vortex fixes and 52 investigative missions. In addition to the levied vortex fixes, 150 supplemental fixes were also obtained. The number of levied investigative missions has increased steadily over the past four years in response to JTWC's increased efforts to detect initial tropical cyclone development.

Of 1979's 28 tropical cyclones, investigative missions were not flown on four. The average vector error for all aircraft fixes received at the JTWC during 1979 was 13.0 nm (24.1 km).

Reconnaissance effectiveness is summarized in Table 2-1 using the criteria as set forth in CINCPACINST 3140.1N.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF LEVIED FIXES	PERCENT
COMPLETED ON TIME	258	89.3
EARLY	2	0.7
LATE	15	5.2
MISSED	14	4.8
TOTAL	289	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7
1979	289	14	4.8

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using imagery data from DMSP polar orbiting spacecraft. Data from similar NOAA spacecraft (TIROS-N/NOAA-6) were not available to the tactical sites of the network but could be processed on a backup basis by the Air Force Global Weather Central (AFGWC).

The DMSP network consists of both tactical and centralized facilities. Tactical DMSP sites are located at Nimitz Hill, Guam; Clark AB, Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that blankets the JTWC area of responsibility in the western Pacific from near the dateline westward to the Malay Peninsula.

The centralized member of the DMSP network is the Air Force Global Weather Central located at Offutt AFB, Nebraska. AFGWC receives worldwide satellite imagery coverage four times daily from two DMSP spacecraft. In addition, AFGWC has the capability to process either TIROS-N or NOAA-6 should one of the primary DMSP spacecraft fail. Imagery taken over the JTWC area of responsibility is recorded on board the spacecraft and later downlinked to AFGWC via command/readout sites and communications satellites. With their coverage, AFGWC is able to fix a storm anywhere within the JTWC area of responsibility. As the only site in the network that receives coverage over the entire Indian Ocean, AFGWC has the primary responsibility for satellite reconnaissance in this area as well as a small portion of the central Pacific near the dateline. On occasion, AFGWC is tasked to provide storm positions in the western Pacific as backup to the tactical sites.

The thread that ties the network together is Det 1, 1WW colocated with JTWC atop Nimitz Hill, Guam. Based on available satellite coverage, Det 1 coordinates satellite reconnaissance requirements with JTWC and tasks the individual DMSP sites to provide the necessary storm fixes. The tasking concept is to fix every storm or tropical disturbance (alert area) once from each satellite pass over the area of the storm. When a satellite position is required as the basis for a warning (levy), a dual-site tasking concept is applied. Under this concept, two sites are tasked to fix the storm off the same satellite pass. This provides the necessary redundancy to virtually guarantee JTWC a successful satellite fix of the storm. Using the dual-site tasking concept, the satellite reconnaissance network was able to meet 98 percent of JTWC's satellite fix requirements. Dual-site tasking is not available over the Indian Ocean since only AFGWC receives the satellite coverage for most of that area.

The network provides JTWC with several products and services. The main service is one of surveillance. With the exception of Osan, each site reviews its daily coverage for any indications of development. If an area shows indications of development, JTWC is notified. Once JTWC issues either an alert or warning, the network is tasked to provide three products: storm positions, storm intensity estimates, and 24-hour storm intensity forecasts. Satellite storm positions are assigned position code numbers (PCN) depending on the availability of geography for precise gridding and the degree of organization of the storm's circulation center (Table 2-2). During 1979, the network provided JTWC with 1970 satellite fixes of tropical cyclones in warning status. A comparison of those fixes made on numbered tropical cyclones with their corresponding JTWC best track positions is shown in Table

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

TABLE 2-3. MEAN DEVIATIONS (NM) OF DMSP DERIVED TROPICAL CYCLONE POSITIONS FROM JTWC BEST TRACK POSITIONS. NUMBER OF CASES SHOWN IN PARENTHESIS.

PCN	WESTPAC 1974-1978 AVERAGE (ALL SITES)	WESTPAC 1979 (ALL SITES)	INDIAN OCEAN 1979 (ALL SITES)
1	13.3 (178)	14.4 (268)	13.5 (7)
2	18.5 (68)	17.9 (61)	23.1 (7)
3	21.2 (270)	18.6 (341)	23.4 (16)
4	25.6 (101)	20.5 (70)	18.0 (8)
5	37.1 (368)	37.8 (605)	34.1 (22)
6	47.2 (190)	43.3 (232)	42.2 (66)
1&2	14.8 (246)	15.0 (329)	18.3 (14)
3&4	22.0 (371)	18.9 (411)	21.6 (24)
5&6	40.6 (558)	39.4 (837)	40.2 (88)

2-3. Estimates of the storm's current and 24-hour forecast intensity are made once each day by applying the Dvorak technique (NOAA Technical Memorandum NESS 45 as revised) to daylight visual data. Satellite derived storm positions, intensity estimates, and forecasts constitute the satellite portion of the JTWC forecast data base.

The availability of satellite data varied during the year. At the start, the network had access to three DMSP spacecraft: F-1 (late-morning), F-2 (mid-morning), and F-3 (sunrise). In June, a fourth DMSP spacecraft, F-4, was launched into a late morning orbit. The network had access to these four spacecraft until mid-September when F-1 failed. Three months later, in early December, F-3 failed reducing the active DMSP fleet to only two spacecraft with similar mid- to late-morning coverages. The network was able to partially compensate for this loss by depending on AFGWC to provide fixes for the entire network based on its unique ability to process TIROS-N as a replacement for F-3. Therefore, the 1979 season ended with available satellite coverage at its lowest point for the entire year.

Besides the network provided fixes, JTWC also receives satellite-derived storm positions from several secondary sources. These include: U.S. Navy ships equipped for satellite direct readout; the National Environmental Satellite Service using NOAA and GOES data; and the Naval Polar Oceanography Center, Suitland, Maryland using stored DMSP and NOAA data. Fixes from these secondary sources are not included in the network statistics.

5. RADAR RECONNAISSANCE SUMMARY

Sixteen of the 28 significant tropical cyclones occurring over the western North Pacific during 1979 passed within range of land based radars with sufficient cloud pattern organization to be fixed. The hourly and oftentimes, half-hourly land radar fixes that were obtained and transmitted to JTWC totaled 1143.

The WMO radar code defines three categories of accuracy: good (within 10 km (5.4 nm)), fair (within 10-30 km (5.4-16.2 nm)) and poor (within 30-50 km (16.2-27 nm)). This year, 1139 radar fixes were coded in this manner; 25% were good, 29% fair and 46% poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 15 nm (28 km).

Of the 16 tropical cyclones which were monitored with land radar, 11 were typhoons: Alice, Cecil, Ellis, Hope, Irving, Judy, Mac, Owen, Sarah, Tip and Vera. These 11 typhoons accounted for 89% of all radar fixes received for this season. Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult and erratic tracks.

The 54 WRS made four radar center fixes from their WC-130 aircraft when actual penetration was restricted. One ship radar center fix was received on Typhoon Bess. No radar fixes were received on Indian Ocean tropical cyclones.

6. TROPICAL CYCLONE FIX DATA

A total of 3318 fixes on 28 northwest Pacific tropical cylones and 166 fixes on 7 northern Indian Ocean tropical cyclones were received at JTWC. Table 2-4, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are also indicated.

Annex B lists individual fixes sequentially for each tropical cyclone. Fix data is divided into four categories: Satellite, Aircraft, Radar and Synoptic. Those fixes labeled with an asterisk (*) were determined to be unrepresentative of the surface center and were not used in determining the best tracks. Within each category, the first three columns are as follows:

FIX NO. - Sequential fix number

TIME (Z) - GMT time in day, hours and minutes

FIX POSITION - Latitude and longitude to the nearest tenth of a degree

Depending upon the category, the remainder of the format varies as follows:

TABLE 2-4. FIX SUMMARY FOR 1979

FIX SUMMARY

	AIRCRAFT	DMSP	TIROS-N	GOES3	RADAR	SYNOPTIC	TOTAL
WESTERN PACIFIC							
TY ALICE	43	80	-	5	42	-	170
TY BESS	17	47	-	-	1*	-	65
TY CECIL	29	87	-	-	51	-	167
TS DOT	7	71	-	-	12	3	93
TD 05	-	20	-	-	11	2	33
TY ELLIS	12	66	-	-	14	7	99
TS FAYE	14	48	-	-	-	5	67
TD 08	1	29	-	-	-	7	37
ST HOPE	22	78	-	-	44	1	145
TS GORDON	8	40	-	-	25	-	73
TD 11	6	33	-	-	-	2	41
TY IRVING	25	124	-	-	148**	-	297
ST JUDY	26	140	-	-	177	2	345
TD 14	3	23	-	-	-	2	28
TS KEN	5	41	-	-	73	-	119
TY LOLA	17	63	-	-	-	-	80
TY MAC	14	86	-	-	55***	-	155
TS NANCY	-	33	-	-	-	15	48
TY OWEN	34	87	-	-	312	8	441
TS PAMELA	5	9	-	-	-	-	14
TS ROGER	6	32	-	-	-	6	44
TY SARAH	13	112	-	-	5	4	134
ST TIP	59	99	-	-	109	-	267
ST VERA	14	54	-	-	60***	9	137
TS WAYNE	11	44	-	-	-	1	56
TD 26	2	11	-	-	-	1	14
TY ABBY	40	66	7	-	-	3	116
TS BEN	4	20	2	-	7	-	33
TOTAL	437	1643	9	5	1146	78	3318
% OF TOTAL NO. OF FIXES	13.1	49.5	.3	.2	34.6	2.3	100

	DMSP	TIROS-N	SYNOPTIC	TOTAL
INDIAN OCEAN				
TC 17-79	28	5	-	33
TC 18-79	16	4	5	25
TC 22-79	8	2	2	12
TC 23-79	30	6	1	37
TC 24-79	19	3	-	22
TC 25-79	17	-	-	17
TC 26-79	20	-	-	20
TOTAL	138	20	8	166
% OF TOTAL NO. OF FIXES	83	13	4	100

* SHIP RADAR FIX
** INCLUDES TWO ACFT RADAR FIXES
*** INCLUDES ONE ACFT RADAR FIX

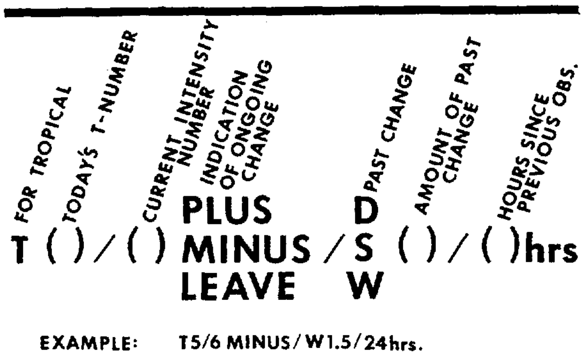
a. Satellite

(1) ACCRY - Position Code Number (PCN) (see Sec. 5) or Confidence (CONF) number (see table 2-5) is listed depending on method used to determine the fix position.

TABLE 2-5. CONFIDENCE (CONF) NUMBERS AS A FUNCTION OF DVORAK T NUMBER AND RADIUS OF 90% PROBABILITY AREA (NM).

TROPICAL CYCLONE INTENSITY	CONF (1)	CONF (2)	CONF (3)
T1.5	60	120	170
T2.0	60	120	170
T2.5	60	120	170
T3.0	50	100	150
T3.5	45	90	140
T4.0	45	90	140
T4.5	45	90	140
T5.0	40	90	130
T5.5	40	80	130
T6.0	40	80	130
T6.5	30	70	120
T7.0	30	70	120
T7.5	30	60	100
T8.0	30	60	100

(2) DVORAK CODE - Intensity evaluation and trend utilizing DMSP visual satellite data. (For specifics refer to NOAA TM; NESS-45)



(3) SAT - Specific satellite used for fix position (DMSP 35, 36, 37 or 39, TIROS-N or Geostationary Operational Environmental Satellite (GOES, 135W)).

(4) COMMENTS - For explanation of abbreviations see Appendix.

(5) SITE - ICAO call sign of the specific satellite tracking station.

b. Aircraft

(1) FLT LVL - The constant pressure surface level, in mb, maintained during the penetration. 700 mb is the normal level flown in developed cyclones due to turbulence factors with low-level missions flown at 1500 ft.

(2) 700 MB HGT - Minimum height of the 700 mb pressure surface within the vortex recorded in meters.

(3) OBS MSLP - If the surface center can be visually detected (e.g., in the eye), the minimum sea level pressure is obtained by a dropsonde released above the surface vortex center. If the fix is made at the 1500-foot level, the sea level pressure is extrapolated from that level.

(4) MAX-SFC-WND - The maximum surface wind (knots) is an estimate made by the ARWO based on sea state. This observation is limited to the region of the flight path, and may not be representative of the entire cyclone. Availability of data is also dependent upon the absence of undercast conditions and the presence of adequate illumination. The positions of the maximum flight level wind and the maximum observed surface wind do not necessarily coincide.

(5) MAX-FLT-LVL-WND - Wind speed (knots) at flight level is measured by the AN/APN 147 doppler radar system aboard the WC-130 aircraft. Values entered in this category represent the maximum wind measured prior to obtaining a scheduled fix. This measurement may not represent the maximum flight level wind associated with the tropical cyclone because the aircraft only samples those portions of the tropical cyclone along the flight path. In many instances the flight path may be through the weak sector of the cyclone. In areas of heavy rainfall, the doppler radar may track energy reflected from precipitation rather than from the sea surface; thus preventing accurate wind speed measurement. In obvious cases, such erroneous wind data will not be reported. In addition, the doppler radar system on the WC-130 restricts wind measurements to drift angles less than or equal to 27 degrees if the wind is normal to the aircraft heading.

(6) ACCRY - Fix position accuracy. Both navigational (OMEGA and LORAN) and meteorological (by the ARWO) estimates are given in nautical miles.

(7) EYE SHAPE - Geometrical representation of the eye based on the aircraft radar presentation. Reported only if center is 50% or more surrounded by wall cloud.

(8) EYE DIAM/ORIENTATION - Diameter of the eye in nautical miles. In case of an elliptical eye, the lengths of the major and minor axes and the orientation of the major axis are respectively listed.

c. Radar

(1) RADAR - Specific type of platform utilized for fix (land radar site, aircraft or ship).

(2) ACCRY - Accuracy of fix position (good, fair or poor) as given in the WMO ground radar weather observation code (FM20-V).

(3) EYE SHAPE - Geometrical representation of the eye given in plain language (circular, elliptical, etc.).

(4) EYE DIAM - Diameter of eye given in nautical miles.

(5) RADOB CODE - Taken directly from WMO ground weather radar observation code FM20-V. First group specifies the vortex parameters, while the second group describes the movement of the vortex center.

(6) RADAR POSITION - Latitude and longitude of tracking station given in tenths of a degree.

(7) SITE - WMO station number of the specific tracking station.

d. Synoptic

(1) INTENSITY ESTIMATE - TDO's analysis of low-level synoptic data to determine a cyclone's maximum sustained surface wind (knots).

(2) NEAREST DATA - Accuracy of fix based on distance (nautical miles) from the fix position to the nearest synoptic report or to the average distance of reports in data sparse cases.